CROP-LIVESTOCK INTEGRATION: THE DYNAMICS OF INTENSIFICATION IN CONTRASTING AGROECOLOGICAL ZONES: A REVIEW[1]

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Summary

This paper examines crop-livestock integration, one of the key dynamics in the process of agricultural intensification. It traces the history of the 'mixed farming' concept, and describes the conventional trajectory of integration of crop and livestock sectors on smallholder farms, as well as the key processes involved. Possible causal factors of crop-livestock integration (other than the Boserupian explanation of population growth) and alternative trajectories of change are explored. Drawing on case-studies from Ethiopia, Zimbabwe and Mali it is concluded that an understanding of the strategies of differentiated social actors and the institutional arrangements that mediate access to resources is essential to our study of crop-livestock integration.

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Introduction

Much of the literature on agricultural intensification talks in terms of the 'inevitability' of rising population density driving the intensification of agriculture towards the greater articulation of crops and livestock. As increases in population occur the premium on land grows as does the availability of labour. The result, it is held, is an 'evolutionary' process of intensification (Boserup 1965, 1981; Pingali *et al.* 1987; McIntire *et al.* 1992; Bourn and Wint 1994; Powell and Williams 1995; de Haan *et al.* 1997), resulting in a move from extensive pastoralism to intensive mixed farming, which is seen as the most efficient and sustainable means of increasing food production (Winrock International 1992).

As Gass and Sumberg (1993) point out this model grounds its analysis in an evolutionary theory of farming systems. This is used to explain not only the casual factors of change in farming systems, but also the direction of change, and the series of logical, orderly and pre-determined stages through which they pass. A cross-section of farming systems are studied with the implicit assumption that they represent points along a limited number of evolutionary paths. There are, however, serious dangers in reading spatial environmental differences as evidence of historical change (cf. Fairhead and Leach 1996).

It is my intention in this paper to draw out some of the problems inherent to this conventional depiction of agricultural intensification through increasing integration of crops and livestock. As an alternative to the linear Boserupian model a tentative attempt is made to sketch a new paradigm for understanding crop-livestock integration. This approach would embrace the complex, highly variable, context specific nature of crop and livestock production systems and recognise that multiple trajectories of change exist.

Such an approach puts social actors and social practices at the centre of analysis. Actors (these might be individuals, households or collectivities) are strategic agents, who actively make trade-offs between livelihood strategies. Also crucial to this analysis is the role of institutions in mediating such choices. Institutions (broadly defined as regularised practices or patterns of behaviour) are the means by which actors gain (or are denied) access to resources. It is thus essential, when exploring the dynamics of crop-livestock integration processes in relation to the pursuit of sustainable livelihoods, to study the trade-offs made by actors and the institutional arrangements that mediate these strategies.

The Mixed Farming 'Narrative'[3]

Ramisch (1996) traces the origin of the 'mixed farming' concept in Africa to the Anglophone colonies where colonial administrators and settler farmers sought to recreate the Western European homestead and owner-manager farming systems on African soil, convinced of their superiority.[4] Colonial accounts 'berated the African farmer for squandering the potential of his land through 'primitive' slash-and-burn practices, and the ever-itinerant pastoralist for ignoring the potential benefits of his abundant livestock (especially their draught power)' (Ramisch 1996: 8) (see, for example, Lugard 1922; Herskovits 1926; Curasson 1948;

[3] A narrative is a simplified story which packages and labels issues so that they appear to be universally applicable and therefore amenable to standardised 'blueprint' policies (see Roe 1991).

[4] Western perceptions of farmers and herders as representing antithetical, autonomous and antagonistic groups also date from the colonial period. This can be contrasted with more fluid and dynamic models of farmer-herder relations which see the two as not necessarily separate (Zuppan 1994).

Alvord 1930). The single 'mixed farming' concept was therefore promoted - a farming system where all the components (cropping, tillage, soil fertility, milk and meat production) are owned and managed as a single unit. It was seen as a means of organising and rationalising, through sedentarisation, both shifting cultivation and pastoral production systems (Gass and Sumberg 1993) and reducing the level of environmental degradation which was assumed to be resulting. The challenge for development is still often seen as to push farmers and pastoralists towards this 'ideal-type' mixed farm.

The current conventional wisdom on crop-livestock integration (as espoused by McIntire *et al.* 1992; Winrock International 1992; and Pingali *et al*. 1987), in accordance with the Boserupian model, sees the development of mixed farming as the 'natural' result of increased population pressure (Gass and Sumberg 1993). Crop-livestock interaction follows an inverted U-trajectory through time:

> First, specialised farming and herding societies that trade products give way to mixed farming societies, in which cropping and animal activities are all in the same management unit. This movement to mixed farming, which we call the first transition, occurs when opportunities for using less labour intensive techniques of soil fertility maintenance are exhausted as population densities increase, and as the opportunity cost of labour rises. The latter encourages farm mechanisation, usually via animal traction; as draught power becomes more valuable, crop farmers start to manage livestock and herders begin to cultivate. As exogenous markets and technologies develop further, there is a reverse movement away from integration towards specialisation, which we call the second transition. These technical changes - fertilisers replacing manure, tractors replacing animals, and supplements replacing fodder crops and pastures - eliminate the cost advantages for a mixed farming enterprise to provide some of its own inputs. As population density rises, causing land pressure, resource competition occurs within the farm which induces further specialisation (McIntire *et al*. 1989 quoted in Mortimore 1991: 27-28).

As population increases, mobile pastoralists are held to be liable to cause too much damage to crops, and the shorter fallows encourage weed infestation. This increases the demand for on-farm energy to deal with it, and so the need for animal traction increases. As a consequence, croppers start to acquire their own animals and on-farm integration starts (Sandford 1988). This also removes the transaction costs for farmers of negotiating contract herding or manure-crop exchanges with herders. A parallel trend is seen as the diversification by pastoralists into cropping as a risk management strategy.

This model is valuable in that it provides a rationale for linking sustainable environmental management with high human and livestock densities in contrast with Malthusian thinking. However, it could be argued that this Boserupian trajectory is an overly narrow, linear and deterministic interpretation of the dynamics of change within farming systems. Although to criticise the mixed farming model for its beguiling simplicity is not to deny its usefulness.

The Component Processes of Crop-Livestock Integration

The case for integrating animal and crop systems is based on the premise that by-products from the two systems are used on the same farm, and draught power, use of roughages and low quality feeds, closed nutrient cycling through the soil, plants and the animals' manure, and improved soil fertility contribute to overall higher outputs per animal and per hectare (Mohammed Saleem 1997). Some of the key aspects of crop-livestock integration, and the trade-offs to farmers they entail, are outlined below.

- **Manure:** manuring is viewed by many as the critical technological component driving agricultural intensification at its early stages (Turner 1995).[5] Animal manure makes nutrients more immediately accessible to crops than green manure or mulching, and allows the concentration of nutrients from more distant, rangeland sources on farmers' fields. Manure from livestock may contribute as much as 35 per cent of soil organic matter (Steinfield and de Haan 1997). There is some debate over the most efficient, traditional animal and manure management practice for maximising nutrient cycling - penning livestock on fields overnight where they deliver their manure directly to the soil (Powell and Williams 1993) or keeping animals in the farm compound overnight and collecting their droppings to transport to the field. The choice of method depends mainly on the attributes of the field and the endowments of the household (Gavian 1993).

- **Crop residue:** crop residues are used for a variety of purposes - one is as livestock feed; this constitutes another key link between cropping and animal keeping.[6] The straw of cereals and grain legumes provides valuable feed after harvest. Sandford (1988) claims that, in integrated farming systems, cattle derive up to 45 per cent of their total annual feed intake from crop residues and up to 80 per cent during critical periods. Crop residues can be grazed *in situ* or gathered for stall feeding.

- **Other fodder sources:** growing forage crops is costly and means sacrificing land otherwise put into food crops. As a result it is relatively uncommon in smallholder mixed farms in Africa. However pastures and fodder fields absorb more water that row-crop fields and leguminous fodder plants also improve soil fertility (Mearns 1996), and schemes for the in situ conservation of sown legumes in 'fodder banks' have had some success in West Africa (Mohammed Saleem 1997). Leguminous trees (such as *Leucaena*) are sometimes planted as a source of fodder to bridge the dry season deficit (Leach and Mearns 1988). Fallow land is also sometimes used as temporary pasture (Bayer and Waters-Bayer 1995). Again the trade-off for farmers is between open-grazing or cutting and carrying fodder for stall feeding (this obviously has heavy labour requirements). In peri-urban areas the use of agroindustrial by-products such as oilseed cakes as cattle feed is increasing.

[5] See Bayer and Waters-Bayer (1995); Powell and Williams (1993); Bationo *et al*. (1995); Landais *et al.* (1991).

[6] See Dugué (1985); Gavian (1992); Reed *et al.* (1988); Sandford (1988); Tiffen *et al.* (1993); Bationo *et al.* (1995).

- **Animal traction:** livestock in mixed farming systems offer the additional potential benefits of draught labour for cultivation, weeding, and transport. McIntire *et al.* (1992) claim that farmers who adopt animal traction can expand area under crops by 25 per cent or more. It requires high initial capital investment and is most common in African farming systems where high value-added cash crops are grown.

Development efforts to date have largely focused on encouraging the more widespread adoption of manuring, fodder cropping and animal traction under the mixed farming (at the individual household level) management model (Turner 1995).

Alternative Causal Factors and Trajectories of Change

As Gass and Sumberg (1993: 14) argue 'much livestock research and development policy in Africa has been, and continues to be, constrained by a narrow and distorted view of the relations between livestock, their owners and managers, the environment and the larger social and political context'. There are various factors that have an important impact on the adoption of farming practices and the evolution of mixed farming systems that lie outside the Boserupian logic formed around population and land pressures. A selection of these are summarised in Box 1 and described in more detail below.

Box 1: Explanatory factors in crop-livestock integration

- population/labour availability
- land availability
- market proximity
- national government policy
- structural adjustment programmes
- reduced trypsanosomiasis threat

Alternative Causal Factors in Crop-Livestock Integration

Research has indicated that the integration of crops and livestock, and agricultural intensification generally, can be driven as much by market forces and policy developments as by population growth (Mortimore and Turner 1993; Goldman 1993; Tiffen *et al.* 1994). In Côte d'Ivoire, for example, agricultural intensification, as measured by the expansion of animal traction, has been strongly influenced by a succession of colonial and post-colonial rural development programmes under changing social and economic conditions. The expansion of oxen since the mid-1970s has been linked to farmer access to credit in the context of the government's subsidised cotton development programme. The growth of mixed farming has also been contingent upon the availability of animals provided by immigrant Fulani herd owners who have been attracted to the country by a variety of economic conditions (Bassett 1994).

In much of Africa, the removal of subsidies for inorganic fertilisers as a result of structural adjustment programmes (together with exchange rate devaluation, high inflation, retrenchment and reduction in remittance flows with real wage levels) has put a higher premium on manure and locally produced biomass sources of soil nutrients (Scoones and Toulmin 1995). Similarly high importation costs and structural adjustments are creating greater incentives for finding renewable feed resources. As grazing land is taken up by arable cropping natural feed must be replaced by crop residues, and livestock owners have less incentive to grow forages (Mohammed Saleem 1997).

Raynaut (1997) found that, in the case of the intensification of the rain-fed production systems in the cotton-growing zone of southern Mali, the adoption of animal traction techniques is not the result of demographic pressure. Rather, it is the existence of a large area of available land that has encouraged this technological transformation that was initially given impetus by development intervention. Similarly studies by Marchal (1983), of the Burkinabé Yatenga, and Raynaut's (1984), of Niger's Maradi, observe a move towards extensive, land-consuming practices in conditions of rapid population growth.

The substantial decline in the threat of trypsanosomiasis in many regions across Africa is another factor to be considered in the expansion of cattle distribution and animal husbandry practices to farming areas (Bourn and Wint 1994).

To mention these alternative causal factors is not, however, to disregard the importance of population density. Where populations are low (as where permanent or temporary out-migration has occurred) labour shortage can be a key constraint to crop-livestock integration. Delgado (1979) attributes a lack of crop-livestock integration in Burkina Faso, in particular the slow rates of adoption of animal traction technologies, to the opportunity cost of labour incurred in terms of foregone agricultural output in the rainy season and migration in the dry season, when a member of the household is delegated to the care and maintenance of a pair of work oxen. The potential benefits from using an ox-drawn plough - expansion of area and increased yields per hectare - cannot be realised because of shortages of labour to carry out the weeding and harvesting of this larger crop output (Toulmin 1983). In some areas of Senegal where 70-80 per cent of the men leave the villages during the dry season to work in Dakar the shortage of male labour reduces the ability to transport manure to the fields (David and Ruthven 1993). In another study Delgado (1989) shows how farmers investments of time and money in mixed farming in Burkina Faso has been directly affected by the growth or stagnation of the coastal cities and the urban income generation opportunities resulting. The relative attractiveness of off-farm investment, and the lure of migration to cities, compared to investing in livestock or establishing relations with those who have animals, particularly in a context of increased personal control over land-holdings and hence more individual decision making, can work against a trend for greater crop-livestock integration (Ramisch 1996; Matlon 1987; Berry 1984).

Given the variety of dynamics involved 'to use population growth as the sole factor for predicting changes in land-use intensity over a wide range of population densities and historical circumstances is questionable' (Turner 1995: 438).

Alternative Trajectories

As Turner (1995: 438) points out: '[a]lternative intensification strategies with labour organised at higher levels of social organisation [e.g. between households] and/or using different technologies are also often not considered in Boserupian intensification models. This void is all the more surprising given ... the continued importance of labour scarcity in highly populated zones' (see Delgado 1979, 1989; Bartholomew *et al.* 1992).

Most of the literature on crop-livestock integration is heavily focused on cattle. However other forms of livestock and livestock production play extremely important roles in livelihood strategies throughout Africa particularly for women and other marginalised groups who generally have limited access to and control of high quality land and other productive resources necessary for mixed farming (Gass and Sumberg 1993). Keeping ruminant livestock is an integral part of smallholder farming systems throughout the tropics (Morrison 1990), implying a different form of nutrient cycling (Harris 1996) as the manure might be used by different actors for different purposes. For example goat manure tends to be used by women for their home gardens in Zimbabwe. Goat and sheep sales are also useful for mobilising cash during drought or for school fees. Cattle are valuable assets which are risky to sell whereas goats and sheep are relatively less valuable and their high growth rates allow for rapid population recovery (Scoones and Wilson 1989). Starkey (1997) claims that donkeys and cows are increasingly replacing oxen as the main work animals in much of Africa. In Zimbabwe drought conditions and pressure on land have led farmers to start to use donkeys (Scoones *et al.* 1996), despite preferring oxen for strength and status, and donkeys are increasing in value relative to cattle (Starkey 1997). Broadening the focus to implicate livestock other than cattle, then, means that the livelihood strategies of a wider range of actors are considered, and that trajectories of change that lie outside the conventional model are acknowledged.

It is not always warranted to infer that sedentary agriculturalists' accumulation of livestock stems from a desire to 'integrate' the crop and livestock production systems (Turner 1995). For this to be the case it would have to be demonstrated 'that livestock are being purchased more for their traction power and manure than for their historic role in [West Africa] as a growing source of capital that can be tapped for a range of expenses' (Turner 1995: 439) and used as an inflation-proof store for cash surpluses (von Kaufmann and Shapiro 1994 and see also Bayer and Waters-Bayer 1995; Sandford 1988).

Attempts to bring about a rigidly defined conception of mixed farming have tended to focus on the introduction of technical packages such as ox-ploughing technology. However in much of sub-Saharan Africa animal traction has suffered from very low adoption rates and often failed to produce the expected intensification effects. Rather than being a labour saving technique, animal traction has led to area expansion (van den Brink *et al.* 1995; Pingali *et al.* 1987)[7] and the early years of animal traction use represent a substantial financial burden on the farmer (Panin 1989; Jansen 1993; Seur 1992). Many studies show that growing cash crops is very often a prerequisite for the adoption of animal traction (Adesina 1992; Delgado

[7] See also: Astake and Mohammed Saleem (1996); Ehui and Polson (1993); Morton and Mathewman (1996); Sandford (1988; 1989).

1989; Jansen 1993). Yet, as Ramisch (1996) points out, the conventional wisdom holds that the failure of many African farmers to adopt animal traction is a problem to be overcome and

> 'there is often an unwillingness to recognise that the farming systems [being studied] may in fact already be very 'mechanised' [see McCann (1995) and below] or that the crop and livestock components are quite integrated, simply because these mechanisations and integrations have not conformed to the expected model' (Ramisch 1996: 9)[8].

Seur (1992), for example, writing about Serenje District in Zambia, shows that agricultural intensification with increased population density does not necessarily mean that the plough replaces the hoe when the shortening of fallow periods has reached a certain level (cf. Boserup 1965: 28-34). Different individuals respond in various ways to land scarcity caused by increasing population density, and the choices and decisions farmers make regarding the use or adoption of new agricultural technology, such as the ox-plough, are not only informed by problems relating to agricultural production and land scarcity, but are also based on other considerations. The plough has been adopted, not as a necessary response to population pressure, but mainly because this technology enabled farmers to produce more crops for sale. Those living in the most densely populated areas, who control very small tracts of land and have no space to extend their fields tend to continue to use the hoe.

Unsustainable Mixed Farming

It is important to note, as Adams and Mortimore (1997) do, that there is no reason to expect a simple relationship between intensification, or crop-livestock integration, and environmental sustainability. Some view the process of mixed farming as inherently unsustainable, pointing out that there are strong biophysical limits to the intensification of agriculture through greater crop-livestock integration. Many argue that conversion of existing cropped areas to continuous cropping cannot be supported solely by manuring (Sandford 1989; Turner 1995; van Keulen and Breman 1990). Except in sparsely cultivated areas, the livestock required to support continuous cropping cannot be maintained by local pastures without external inputs.[9] Over the long-term, such nutrient transfers cannot be sustained; nutrient outflows from pastures will exceed inflows (nutrient 'mining') resulting in a combination of reductions in livestock productivity, manure quality, pasture productivity and local livestock presence (van der Pol 1992; Turner 1995; de Leeuw *et al.* 1995). Thus many researchers, particularly in Francophone West Africa, have argued that intensive mixed farming over a long period is not possible without large areas of rangeland to support the system.[10] However talking about nutrient cycling simply in terms of inflows and outflows, and deficits and surpluses sometimes

[8] The expected model, in this case, is the 'mechanisation ladder' progressing from hoe cultivation, through a series of oxen-drawn implements, to tractor cultivation The model is well established in much of Africa, and has been at the heart of government policy in the Gambia for example (Sumberg and Gilbert 1992).

[9] External inputs of phosphate and nitrogen can take the form of fertilisers or animal feed supplement.

[10] This conclusion is not born out by Harris's (1996) study of agricultural intensification in the Kano Close-Settled Zone of Nigeria.

implicitly assumes that technical interventions are all that is needed to make up the balance. Such approaches fail to recognise the importance of social institutions in processes of environmental management (Scoones 1997b). Institutions such as labour-sharing and barter-exchange between different groups above and below the level of the household are, in fact, crucial in maintaining soil fertility (Turner 1995).

Multiple Trajectories - Case Studies

In order to consider alternative trajectories of agricultural intensification through crop-livestock integration it is illustrative to present some detailed case studies. These are taken from Ethiopia, Mali and Zimbabwe and were chosen because they illustrate some of the key dynamics across a range of scales and agroecological settings. These key dynamics include changing political contexts, flexible institutional arrangements and social differentiation.

Mixed Farming

In the case of the first example, taken from James McCann's study of Ada District in Ethiopia, the conventional trajectory of change is broadly accurate. However this nuanced and complex historical analysis shows that these changes were driven as much by land reform and political changes as by population increase [see Case Study 1].

Case Study 1: Ada District, Ethiopia [James McCann (1995) *People of the Plow* - Chap. 6] - A conventional mixed farming system?

The Ada District, 50 km south of Addis Ababa has been Ethiopia's most intensive and specialised smallholder, ox-plough economy. Population growth and in-migration to agricultural zones around the city has meant strong markets for food crops and meat and promoted the conversion of open land to cropping and pushed the agricultural and livestock economies towards a 'closed' agricultural system, that is, with little or no open resources in land or forage. The agricultural history of Ada District is wrapped up in the intensive engagement of an ox-plough economy with a burgeoning capital city and the transformation of a national political economy.

The relationship between population increase and agricultural practice in the ox-plough agricultural system is a function of the interaction between crop and livestock production, the gradual expansion of cropped land at the expense of pasture. As an agricultural system the ox-plough complex has been dependent on its ability to sustain both its livestock population and the expansion of cropped land, a relationship fundamental to its movement over time and its expansion across the highland landscape. McIntire *et al.*'s (1992) generative description of crop-livestock integration and population parallels farmers' own subjective accounts of agricultural change over their lifetime (see also Gryseels 1988).

A conjuncture of factors, including population pressure, a revolution and land reform in the 1970s, access to inputs and agricultural extension advice, and the emergence of a large urban market for food, has pushed ox-plough cultivation toward intensification of land use and specialisation in a single crop (teff). Ada's settlement history and its effect on agricultural history is conceived of in terms of the evolution of a relationship between Ada's agricultural and livestock economies and their engagement with the political economy of the Shewan state and, subsequently the emerging national economy.

In the late nineteenth century Ada was incorporated into the Shewan state. In 1886 the state's capital was moved to Addis Ababa, altering the relationship of the state with the southern periphery populations and their local economies. Ada's proximity to the capital meant it received the new tenurial status of *matabet* (kitchen or pantry). This feudal arrangement meant that land tenure and tributary obligations focused on providing food directly to the imperial palace. At this stage agriculture coexisted with a powerful and largely autonomous livestock economy, only weakly integrated with the ox-plough farm economies. There was no forage market, and only a minimal exchange of cereals. At the beginning of the twentieth century new migrants were drawn to Ada, in part by concessionary tenurial arrangements. Farm sizes were still small reflecting the lack of incentives to expand area under crops or to integrate the crop and livestock sectors, rather than pressure on land. Soil fertility was maintained by crop rotation strategies well adapted to local conditions and to a much lesser extent by fallowing.

The Italian occupation of 1936-41 brought ambitious capital-intensive schemes for the expansion of modern agriculture in the highlands by Italian farmers of which few materialised. The main legacy to agriculture was the establishment of a market and administrative centre at Bishoftu, which was to become Dabra Zayt, a post-war boom town which fed on the rising values of land and a specialised form of landowner-tenant agriculture [where it was common for tenants to become landowners or to serves a tenant for several landowners at once.] Y*et al.*though the population increased dramatically in the post-war years crop-livestock integration was still weak.

By the late 1960s the conjuncture of population growth, market and the green revolution transformed the basic elements of Ada's ox-plough cultivation. The critical indicator and driving force of this transformation was the intensification of crop-livestock integration. This experience bears out McIntire *et al.*'s (1992) contention that 'growing constraints on obtaining inputs in markets and contracts ... create cost advantages in providing inputs directly on farm, thus encouraging crop-livestock interaction'. Population growth brought about the inflation in the price of land relative to that of labour and the consequent expansion and/or introduction of high value crops. As a means of increasing cropped land within their holdings landowners recruited relatives as tenants. These two factors were the driving force in the evolution of landowner-tenant relations. These relations were complex, varying by farm and between farmers and one or several landowners. The formal sharecropping arrangements hid informal, but normative, arrangements benefiting the tenant, who in turn was expected to perform some uncompensated tasks. New practices were designed to intensify labour and increase cropped land at the expense of pasture and fallow were imposed, such as making fallowing a punishable offence. Since livestock was the property of the tenant, the landowner had little interest in improving or maintaining forage or providing pasture.

The agronomic system was approaching closure in the early 1970s, with little or no open resources in land or forage. The apparent irony is that the pressure to increase cropped land in the closing system placed a premium on oxen ownership (for ploughing) to maintain productivity but reduced the pasture to sustain these oxen. This paradox is explained, again in accordance with McIntire *et al.*'s trajectory, by the fact that cropping changes the seasonal pattern of fodder supply, with crop residues providing animal fodder in the post-harvest and dry seasons when pastures are least abundant. Farmers in Ada had the added incentive that crop residues were direct farm products subject to their own management, and not landowner control (which was not the case with rented pasture). However the dependence on dung as fuel has meant that manure has not been available for use as fertiliser. The local market for dung cakes has, though, been an income-earning opportunity for women and stall feeding means it is easier to collect and dry.

After the 1975 Revolution land reform brought major tenure changes. The new rules provided for tenure through claims to residence in a peasants association, and this encouraged new land claims causing increased pressure on cropped land. Membership in producer co-operatives gave farmers special access to fertiliser and extension advice but removed them from direct control over decision-making.

McCann concludes that the ‘evidence of intensification of farm economies in Ada suggests that the population's pressure to increase cropped land has forced more efficient use of on-farm and industrial by-products to sustain livestock and the domestic domain (fuel, building materials, milk). The integration of small farms with urban markets, the agroindustrial sector, and urban sources for inputs (improved seeds and fertilisers) has, however led these farms away from self-reliance toward further dependence on events and policies on the national political economy. The emergence of new agronomic applications of the basic ox-plough technology associated with this intensification affirms that system's resilience but expands farmers' vulnerability to new conjunctures of politics and the environment' (p.263).

In the Zimbabwe case-study it is a combination of increased population pressure and technological changes (particularly the arrival of the plough and the cart) and the flexible institutional arrangements concerning their use, that have encouraged crop-livestock integration [see Case Study 2].

Case Study 2: Chivi District, Zimbabwe (Scoones *et al.* 1996; Scoones 1997a)

Chivi is a relatively poor District in the dry south of Zimbabwe. In the early years of the twentieth century farmers in the district largely rejected colonial extension advice, preferring low-input, land-extensive opportunistic dryland farming to the labour-intensive crop rotation and manure fertilisation recommended. However, by the 1940s a combination of increased population pressure and technological changes encouraged intensification. In particular investment in carts meant that manuring was increasingly practised. Manure treatment through adding crop residues or other vegetable matter to the *kraal* is also common practice. The expansion of arable areas has reduced available grazing land. Livestock must increasingly rely on small patches of grazing within the landscape, and field-edge grazing and crop residues are key to dry season animal nutrition.

Since the arrival of the plough this century livestock, for draught, has become an increasingly important production input (as well as an important source of exchange entitlement in times of food shortage). As a consequence various types of institutional arrangements for sharing draught power are vital to the pursuit of sustainable livelihoods (such as conditional loans, exchange relationships, hiring and beer parties.). The negotiation of draught access can be a complicated affair. Social networks and relationships form the basis on which sharing and exchange arrangements are negotiated. Such institutions are not static - the drought of 1991-92, for example, dramatically reduced the availability of draught power, requiring networks based on draught sharing relationships to be transformed (kin-based draught sharing arrangements were replaced by an increasing individualisation of production and some degree of commercialisation).

Chivi's agricultural landscape has been shaped by particular conjunctures of events which have precipitated changes in farming strategies which, in turn, determine the pattern and path of crop-livestock integration. Since the 1960s a combination of population pressure, colonial land reorganisation, destocking policies, environmental legislation banning riverine and wetland cultivation, and changing sexual divisions of labour (as men have been drawn to the wage economy) has lead to major shifts in farming styles. An example has been the emergence of intensively managed field and garden sites around homesteads and in valley areas which have increasingly been the primary site for the application of available manure (including goat and poultry manure).

Farmer-Herder Interactions

Crop-livestock integration can certainly occur outside the conventional mixed farming model trajectory, and at a range of scales other than the single farm unit. This is evident where agricultural-pastoral interactions at an intra-regional scale persist on the basis of various forms of herding, manure and fodder supply contract (Scoones 1994 - see Gass and Sumberg 1993; Toulmin 1983; McCown *et al.* 1979). Herding contracts exist where pastoralists care for the herds of sedentary farmers in return for milking rights, or some of the offspring, or payment. Arrangements for forage and manure use between herders and farmers are also common. Bayer and Waters-Bayer (1995) describe these respectively as ranging from open access to stubble fields, to the sale of grazing rights or crop residues to particular herders, and from arrangements for keeping herds overnight on farmers fields to deposit manure to the removal of manure from pastoralists' kraals for sale (see Case Study 3 and also Bonfiglioli 1993; Gavian 1992).

Case Study 3: Kala village, Central Mali (Camilla Toulmin 1983, 1992a, 1992b;)

In Kala, an agro-pastoral village in Central Mali, farmers and herders have continually had to adapt in order to survive and a variety of strategies and institutions are employed to guard against risks. An important trend is in the region is the growing competition between the different groups for access to land and water. This must be seen in the context of: an increasing direct involvement by pastoral groups in cultivation (the terms 'herder-farmer' and 'farmer-herder' are used to describe the blurring of livelihoods previously assumed to be distinct); the attraction of short cycle crop varieties and the importance of manure to farming systems; and the consequent desire of different groups to acquire and maintain control over water supply. The Bambara community of Kala, for example, has asserted its right to control access to water by livestock within its territory so that farmers can acquire the manure they need to expand production of fast-growing varieties of millet. This village's experience demonstrates some of the advantages of the integration of crop and livestock activities and points to the internal adaptability of traditional farming systems in a region where there are high production risks, due largely to climatic variability.

Labour availability; pressure on land and availability of forage and water in the dry season; and widespread ownership of labour saving technologies (such as ploughs and carts) account for the considerable integration of livestock and crop activities in the village.

An important institution is the large extended household which reduces risk faced by individual. In this labour-scarce economy, the establishment and maintenance of a large domestic group within which production and child-bearing take place is given a large priority. Also the establishment of marriage alliances between households in different settlements provides a form of social insurance against disaster in times of localised harvest failure. Larger households tend to have more labour and cash and are better able to invest in cattle, oxen plough teams, marriage expenses and digging wells.

Farmers actively invest in wells with an eye towards engaging in exchanges of manure for watering rights, they dig wells to attract herds to come and water in dry season, in exchange for dung deposited on field. In return for watering their stock at the farmers' well and gaining access to relatively favourable grazing resources, the herder must kraal his animals on the farmers fields overnight. Over a period of several months the kraal will be shifted to allow a more even spread of dung across the land. The long-term returns to such investment must be understood in relation to shifts in economic, environmental and institutional factors. The returns are highly vulnerable to trends in rainfall, the carrying capacity of pastures, and the local balance of power between the Bambara and other groups. Were herders to acquire formal rights to settle and dig wells of their own, farmers would lose this relatively easy and low cost means of acquiring access to manure.

Many farmers are building up their own cattle herds, partly as a source of wealth, and partly to provide access to sufficient manure to enable them to do without visiting herding groups. Although the Bambara farmers also hire herders (usually Fulani - paid in milk and grain) rather than herding their own livestock. This allows them to concentrate on farming during the short rainy season.

Women gain access to manure from sweeping the compound where the sheep, goats and horses are tethered, as 'payment' for the water they bring daily to these livestock. They use this to fertilise their private plots of grain and vegetables.

Institutional relations thus set the pattern of the exchange of resources between different groups and the terms of access. The power balance between ethnic groups at a national and local level, and between men and women at the household level, is important in understanding how and by whom the terms of such exchange relations are set.

In many agroecosytems such 'traditional' crop-livestock integration arrangements are held to be more efficient than orthodox mixed farming. Bayer and Waters-Bayer (1995) maintain that farmers tend to invest less labour than pure pastoralists in animal keeping and put less value on animal-related skills. They also contend that animals in transhumant herds also enjoy a longer herding day and, given the same access to grazing resources, their productivity is higher than that of settled livestock (Bayer 1986; Wilson and Clarke 1976). Transhumant movements also demand considerable organisational capacity and diplomatic skills to negotiate passage rights and access to water and crop residues. If the existing level of livestock productivity

in the drylands were to be maintained, expensive technology and external inputs would have to be introduced to substitute for the herders' indigenous knowledge and management skills (Bayer and Waters-Bayer 1995).

Intensification of resource use via increased mixed farming could lead to the overall decrease of animal production, as farmers' animals, grazing mainly near farms, use forage resources in the wet season which transhumant herders traditionally only used in the dry season. In northern Nigeria Adams and Mortimore (1997) contend that under intensive mixed farming systems the adaptive use of multiple grazing resources in space and time is replaced by a dependency on crop residues, and weeds and tree foliage on the livestock owners' farms through most of the year. This means that flexibility in the management of grazing resources is greatly reduced.

Disintegration of transhumant use of forage resources diminishes national food production and destroys the livelihood base of many herders (Bayer and Waters-Bayer 1995). If pastoral livestock are increasingly incorporated into agro-pastoral areas, and transhumant movement tracking the 'key resources' of the dry rangelands is abandoned in favour of more 'efficient' settled production systems in more equilibrium environments, then the opportunity for exploiting large areas of dry range (via opportunistic/tracking strategies) will be lost (Scoones 1995). Under conditions of land pressure, to encourage the abandonment of dry rangelands may be an inefficient solution. Arguments for mixed farming must, therefore, be tempered by considerations of what efficiency means in a dynamic ecological context (Scoones 1995).

The argument that contracts between herders and farmers relating to crops and livestock are sometimes more appropriate and efficient than mixed farming is, however, brought into question in contexts where there are serious conflicts between the two groups. There is much literature that refers to a pattern of increasing conflict between farmers and herders (e.g. Bassett 1986). This may result in, and be exacerbated by, a decline in herding, manure and fodder supply contracts and a worsening of terms for herders in those contracts remaining. White (1990) describes how the extent and terms of herding contracts for Wodaabe herders in Niger has changed since the 1970s. Previously herders received milking rights and some of the offspring of the contract animals. As many pastoralists lost their herds during drought in the 1970s the number wanting to enter herding contracts increased. By the mid-1980s they were only given milking rights, no longer having the opportunity to reconstitute their own herds through earning offspring and many herders were tending only contract animals (Bayer and Waters-Bayer 1995; Ramisch 1996).

In such cases the adoption of mixed farming is often seen as the means of resolving the perceived conflict between farmers and herders (e.g. Jabbar 1993; McCown *et al.* 1979; Winrock 1992). Yet according to Hussein (1996) there is little empirical evidence that farmer-herder conflict has increased. Rather relations have historically been characterised by varying degrees of cooperation and conflict, depending on circumstances. In Senegal, for example, herders and farmers have joined forces to prevent the intrusion of commercial farmers and maintain the traditional links between crops and livestock (Guèye 1993). However, as Bayers and Waters-Bayer (1995) note, the conventional paradigm in formal agricultural research and the notion of 'modern' farming make it difficult for such 'traditional' crop-livestock integration to gain official backing.

This is not to imply that herders should always focus on stock rearing and reciprocal arrangements with farming groups and avoid cropping (cf. Delgado 1979). Such generalisations are problematic, as some studies have found no significant difference between transhumant and agropastoral livestock (e.g. Wilson 1982), and there are highly efficient mixed farming systems found in the dry areas of southern Africa (Scoones 1992; Abel 1993) where there has been a long tradition of integration (Scoones 1995).

The Key Themes Emerging from the Case-Studies

These case studies show that the farmers' and herders' decisions relating to the management of crops and livestock cannot simply be conceived of as a function of population density and the opportunity cost of labour. A wide variety of interacting ecological, social, economic and political processes come together to encourage or discourage crop-livestock integration and influence its pattern or trajectory over time. The particular conjunction of factors is of course dependent on the particular context and scale of analysis.

The agroecological characteristics of different areas have particularly striking implications for the specific patterns and trajectories of change of the cropping and livestock sectors. Zones with high resource endowments (such as in the Ethiopian case study) tend to be characterised by tight, 'closed' nutrient cycles. This implies little or no fallowing, and practices such as stall feeding of livestock with cut and carried fodder. In zones with low resource endowments (such as the Malian case study) the nutrient cycle is more diffuse, cattle tend to be kraaled on fields and institutional arrangements such as manure exchange between herders and farmers occur. In high resource endowment areas it is likely that the crop-livestock integration trajectory will take the form of the expansion of arable land (with increasing use of crop residues and growth of fodder crops) at the expense of communal grazing land. Conversely in low resource endowment areas, if the main constraint is shortage of livestock for manure and draught, crop-livestock integration may mean expansion of grazing land (Scoones and Wilson 1989).

Two other key issues emerging from the case studies which are of importance in understanding the process of crop-livestock integration are the trade-offs made by socially differentiated actors and the role of formal and informal institutional arrangements in mediating access to resources. It is these to which I now turn.

An Actor-Orientated Approach

The case studies show that aggregate approaches to understanding trajectories of change that make generalisations about rural communities or rural households are inadequate. Where analyses have been performed using averaged data to depict agricultural management typical for the 'farming system' in a region or agroecological zone, the high degree of temporal and spatial abstraction can mean wide inter-household and inter-village variations in crop and livestock management practices are ignored (Turner 1995). Since many of the underlying relationships are non-linear this also introduces potential mathematical error (Turner 1995). The work of Rocheleau (1995) and Murton (1997) is valuable here in that it specifically questions whether Tiffen *et al.* (1994), who rely on aggregate level statistics, accurately reflect the experience of the people who have carried out the environmental transformations in Machakos District, Kenya.

The alternative is a differentiated approach to analysing livelihood strategies, that starts where people are, not where policy-makers and planners think they are, or rather should be.[11] Such an approach should also look beyond individual or household responses to the wider social and economic contexts. African farmers and herders are flexible and dynamic - they have multiple objectives and strategies. The responses to risk and uncertainty while farming and herding necessarily involve continuous adaptive change in farming practice. Farmers are flexible in their use of labour, the crops and grazing resources used, field locations and their exploitation of off-farm income sources They opportunistically exploit variability and diversity in environmental and economic conditions (Adams and Mortimore 1997; Batterbury *et al.* 1996, Scoones *et al* 1996).[12]

With respect to crop-livestock integration this means that 'farmer-herders' or 'herder-farmers' (Toulmin 1983) are constantly making trade-offs between different management options and adjusting their strategies accordingly. Their strategies are influenced by a variety of issues related to access to labour, capital assets, disposable cash income, secure rights over land, the resource endowments of the land, and their management skills and knowledge.

For example it is only when there are significant and secure returns to the extra labour inputs needed to head-load manure to fields or transport it in carts that farmers invest in manure use. Farmers rarely sell manure, although this was a coping mechanism for many poor households in Nigeria during the droughts of the 1970s and 1980s (Mortimore 1989) and in Ada District, Ethiopia, as the case study shows, there is a local market for dung-cakes for use as fuel (McCann 1995). Similarly in certain contexts farmers may be willing to sacrifice the soil-fertility enhancing value of crop residues to meet other needs (animal feed, construction, fuel, medicinal, culinary and household applications etc.) (Gavian 1992; and see Landais and Lhoste 1990; Rabot 1990). Farmers must also choose between allowing their livestock to roam free (if this is possible) or stall-feeding - which entails considerable labour investment.

The point is that these actors have agency - that is to say that they have the capacity to make a difference. Actors actively monitor, interpret and shape the world around them (Leach *et al.* 1997). An analysis of the dynamics of crop-livestock integration must, therefore, begin with an understanding of the strategies and trade-offs of different social actors.

Social Differentiation

Studies of crop-livestock integration trajectories which link case studies as if they are various points on a continuum and ignore institutional dynamics also tend to miss the implications of the fact that actors are inevitably socially and economically differentiated by gender, age, wealth, class, ethnic origin, or locale (Ramisch 1996; Murton 1997). As Morton and Mathewman (1996: 3) mention:

[11] The work of Giddens (1976; 1979; 1984) and Long (1992) provides the theoretical underpinning to this approach - see 'Sustainable Livelihoods: a Conceptual Approach', IDS unpublished mimeo.

[12] Richards (1989) describes farming as a 'performance', a continuous, elaborate response to contingent events.

> ‘the point at which it becomes worthwhile to invest labour in fodder cultivation, construction of haybarns, and manure pits, for example, will arrive at very different times for different households, even within one locality. Similarly, new opportunities for commercialised livestock production will be taken up unevenly by households.’

Many farmers will have only few, if any, animals and it is doubtful whether mixed farming will be an option at all for poor farmers in many densely populated areas (Bayer and Waters-Bayer 1995).

Crop-livestock integration can also have a damaging impact on economic or social well-being of certain actors (Berry 1984; Murton 1997). For example, where weeding and harvesting needs increase a further burden may be imposed on women if they are traditionally responsible for these operations (Nelson-Fyle and Sandhu 1990). Women also tend to be the major providers of fodder and water and haul manure from stalls in intensively managed mixed farming systems (Powell and Williams 1995). The demands on women’s labour are further increased where there is high seasonal male out-migration, as in the Sahel (David and Ruthven 1993). There may also be various cultural constraints to the adoption of animal traction by women (Nelson-Fyle and Sandhu 1990) or by 'traditional' farmers (Sidi Bah 1990).

With respect to pastoralists adopting agriculture there is no evidence of common motives or of a single path to agricultural intensification (Ramisch 1996). As Zuppan (1994) says: 'poor pastoralists farm to survive, but the wealthy invest in cash crops and irrigation to establish land rights'. Thus agricultural intensification and crop-livestock integration follow distinctly 'indigenous' patterns often quite unlike the model of 'mixed farming' proposed by colonial and post-colonial extension services (Ramisch 1996). Alternative pathways (outside the mixed farming model - such as increasing small ruminant ownership) are particularly important for women and other groups who generally have limited access to high quality land and other productive resources, and are likely to become increasingly marginalised (Gass and Sumberg 1993).

Institutions

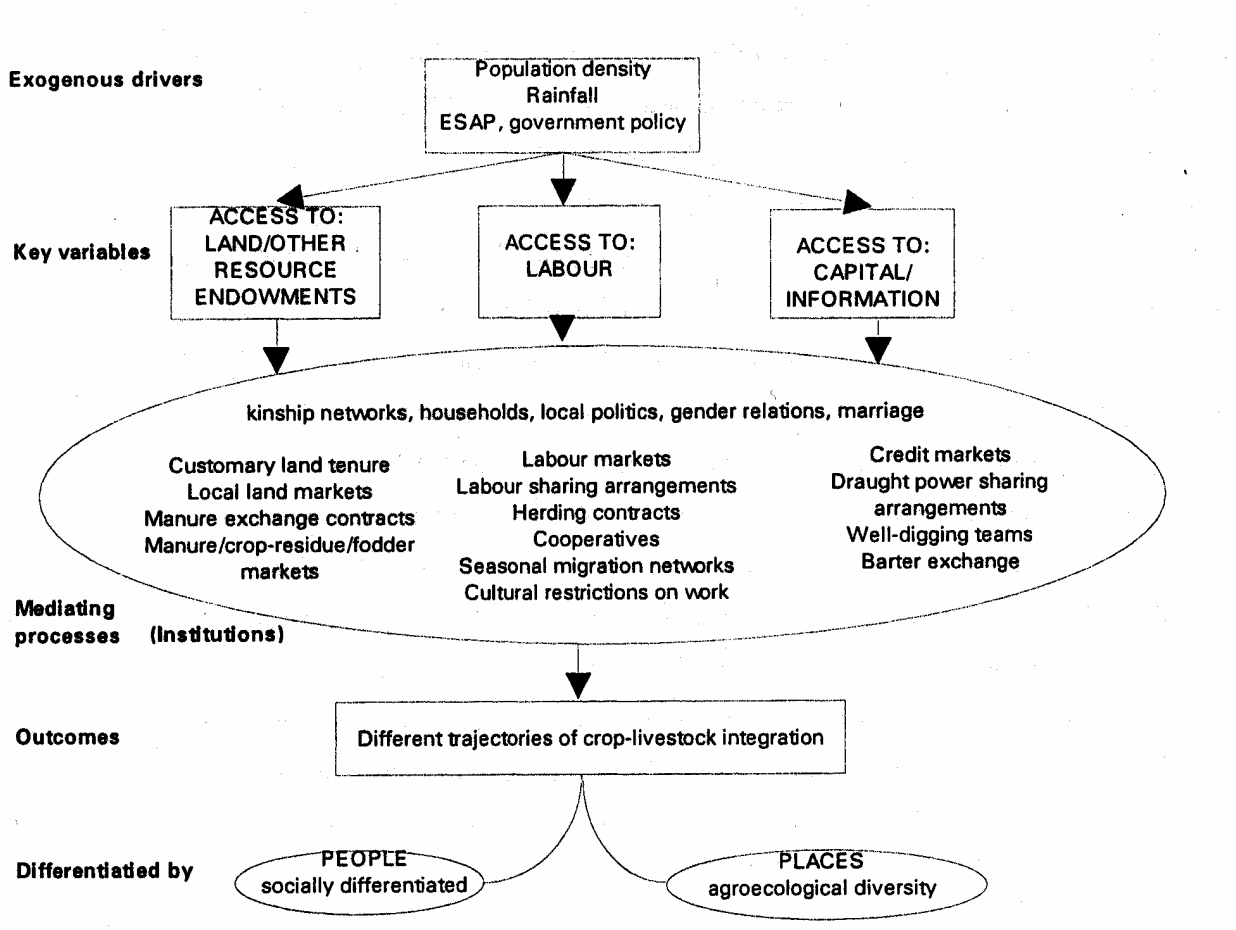
Agricultural practice is a product of social context. Understanding crop and livestock management practices requires insights into the histories of social change as well as environmental change. This in turn requires an understanding of the institutions which mediate this change (cf. Berry 1993). Diverse institutions, both formal and informal, and often acting in combination, shape the ways in which actors access, use and derive well being from environmental resources and services (Leach *et al.* 1997). However the bulk of research on crop-livestock integration has ignored its institutional dimensions (notable exceptions include Scoones and Toulmin 1995; Toulmin 1983; 1992; Turner n.d.).[13] Yet, as the case studies show, the way institutional arrangements mediate access to livestock, manure or fodder, for example, cannot be disregarded.

Figure 1 is a highly simplified representation of some of the key variables and processes which interact to produce differing trajectories of crop-livestock integration for different people and in different places.

[13] Some of the literature that does consider the role of institutions does so in a very functionalist and reductionist way. Jabbar (1993), for example attributes the beef-eating taboo in Hindu India simply to the need to save draught animals for expanding crop production into less fertile areas.

Within the oval are a selection of institutions that mediate access to land and other resource endowments, to labour, to capital and to information. Institutions, here, are defined very broadly as regularised practices or patterns of behaviour (Leach *et al.* 1997), such that the term encompasses such arrangements as: marriage, land tenure, markets, manure exchange contracts, labour and draught power sharing arrangements and cultural prohibitions on certain types of work.

Figure 1: Some of the key factors influencing crop-livestock integration trajectories



Land Tenure

It is perhaps illustrative to examine one such institution in more detail. Land tenure is obviously a key institution in mediating access to grazing land, crop residues and manure. The standard model of intensification holds that property rights will become more individualised with population increase and integration of the crop and livestock sectors (Boserup 1965; Noronha 1988; McIntire *et al.* 1992; Tiffen *et al.* 1994; cf. Lane and Moorehead 1995). However this is inadequate for understanding the evolution of people's strategies and property rights (Swallow 1994). Empirical data from pastoral areas show a lack of clear-cut divisions between property regimes, but rather a complex set of overlapping rights that are continuously contested and renegotiated (Scoones 1995).[14]

[14] See Scoones (1995), Lane and Moorehead (1995), van den Brink *et al.* (1995); and Turner (n.d.) - on arguments for flexible tenure regimes for pastoralists, which support mobility, and a focus on conflict negotiation, mediation and arbitration.

As Case Study 3 illustrates property rights are related to ethnicity, length of settlement and production system. In Kala long-term residents had rights to water from the village well and secure rights to dig their own wells; more recent settlers had second rights to water form the village well and no rights to dig their own wells. Farm households who owned their own wells were better able to capture the manure produced by their own animals and trade water for the manure produced by herders' animals than farmers who did not own wells (Toulmin 1992a; and see Hesse *et al.* 1985; Gavian 1993).

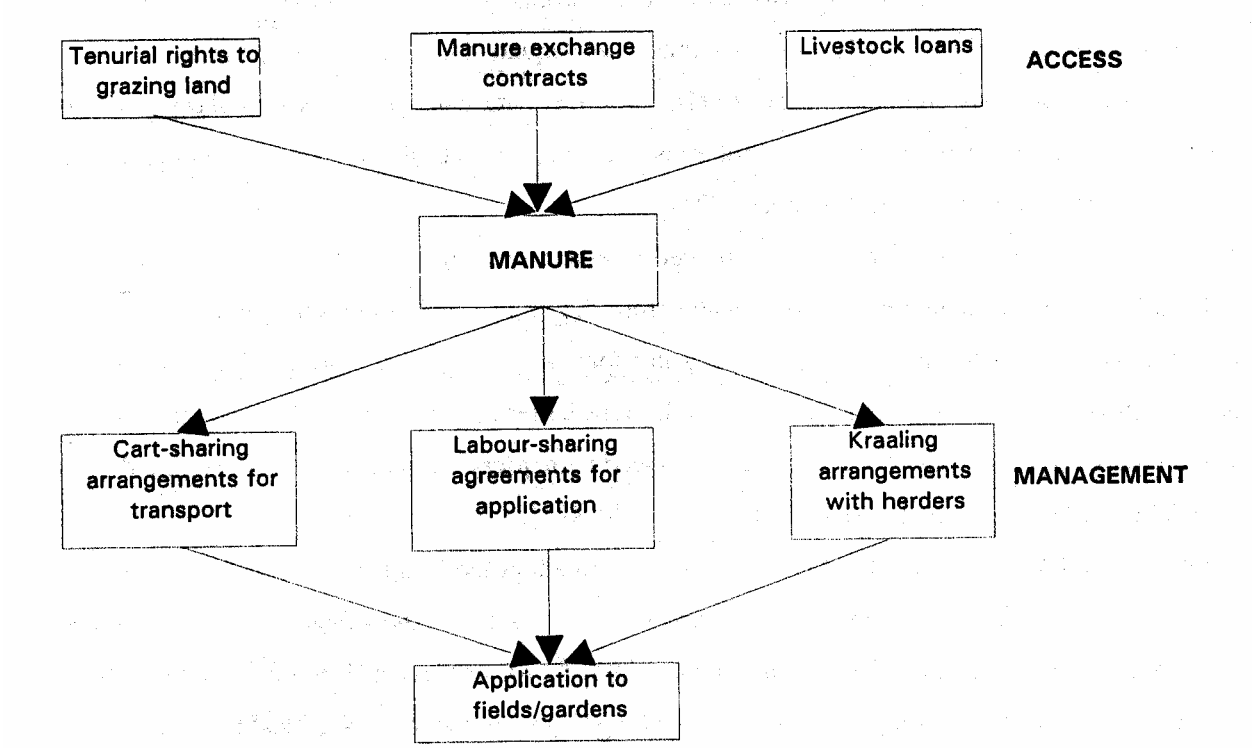
Tenure status of land also tends to affect farmers decisions to adopt land improving investments. Studies show, for example, that security of tenure is an important constraint on the adoption of fodder banks (Taylor-Powell and Ingawa 1986) and alley farming (Jabbar 1994). However Gavian (1993) found no significant differences in the probability of manuring fields held under different types of tenure in Niger and Ethiopia.

Institutional Complexity

Separate institutions do not stand alone but are intimately bound up with each other in integrated crop-livestock systems as Scoones and Toulmin's (1995: 355) detailed description of the socio-economic factors affecting the use of manure show (see also Figure 2):

> 'access to manure will be affected by a range of factors such as the size of a herd and access to manure exchange contracts. The quantity of manure will depend on access to grazing land which will be affected by tenurial rights, as well as the availability of the fodder resource. Manure quality will depend on the type of fodder resource, the management inputs in the livestock pen and the season. The application of manure to arable areas will depend on its transport from livestock pens to the field or the existence of arrangements whereby herders pen their livestock on farmers' fields. Transport will be reliant on access to carts and transport animals, while access to herders' livestock manure will be dependent on establishing mutually acceptable exchange relationships between herders and farmers. Application of manure on the fields will in turn depend on labour availability, while ensuring the effective use of available nutrients for crop growth will be dependent on careful management and timing of manuring in relation to sowing and weeding of the crop.'

Figure 2: Institutions relating to the access and management of manure



The historical dynamics of institutional change are also important. Ignoring them risks removing a large portion of the politics of resource access from the characterisation of society-ecology interactions (Turner 1992; Scoones 1997a). Changing political alignments within the regional political economy might cause shifts in pastoralists' access to grazing land, for example ('traditional' rights are often significantly altered or manipulated in such processes) (Turner 1992; and see Case Study 3 above). Property designations are not fixed but are socially and politically malleable as power relations change over time (Berry 1984). Property rights are, in practice, contested, multi-faceted and negotiable (see Lund 1994; Kabeer and Subrahmanian 1996; Rasmussen and Meinzen-Dick 1995). Similarly the Zimbabwe case study shows how institutional arrangements for sharing draught power are not static. They are continally renegotiated and transformed in response to the availability of draught animals which in turn depends on conjunctures of events such as drought and structural adjustment programmes.

Conclusion

The cross-sectional approach to studying crop-livestock integration which encompasses a number of sites over a range of agro-ecological zones (Bourn and Wint 1994; Pingali *et al.* 1987; McIntire *et al.* 1992) has severe limitations. It is based on the unjustified assumption of a single development trajectory with sites as different stages along it. It is dangerous to infer the validation of a historical process (in this case the Boserup hypothesis) from spatial correlations (Turner 1995). The relationships and outcomes associated with particular crop and livestock production systems are both highly variable and site or context specific, rendering simple generalisations meaningless (Gass and Sumberg 1993). There are differences in local patterns of land types, in livestock management experience, labour availability, prevalence of labour and

draught power sharing, degree of experimentation and so on and this implies a wide variation in local crop and livestock management practices and hence different trajectories of crop-livestock integration. A detailed empirical examination of crop-livestock integration, informed by the theory outlined in this paper, would aim towards reaching an understanding of the trade-offs made by actors and the way institutions are created and transformed by people's actions, and in turn constrain or condition these actions.

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